

# Revolution in communication

**D**URING the last two decades, military radio communications have been revolutionised by the application of solid-state and digital technology.

As a result, equipment has become more versatile, more reliable and, in real terms, less expensive. It is more compact than its predecessors and able to operate with less power.

At the same time, the widespread application of modular design techniques has, to an extent, provided opportunities for tailoring the mix of standard components and subsystems to meet the peculiar requirements of particular users.

Modular design has also been responsible for extending the functional repertoire of certain types of kit; a good example of this is NAPCO's CITO-270 'snap-on' applique which is designed to convert the VRC-12 and other tactical manpack radios for meteor burst working within the space of a few minutes.

The bad news is that the rate of technological change is now such that there is a very real danger of systems becoming obsolete before they are fully fielded. This is only partially offset by the ease of upgrading, which is a product of the increased software content of modern military radio.

In this period, VHF has established itself as the favoured band for short-range land-based communications, and FM as the most common form of modulation. Here, as the reduction in channel spacing has continued, digital frequency synthesizers have played an important part in arriving at the modern forward area equipment.

Tactical systems have become smaller and lighter, to the point where almost identical

By John Williamson

sets can appear as either vehicle communications centres or peripheral manpacks.

Now, the tactical radio which is entirely digital up to the IF stage, is just around the corner.

Progress in long distance communication has been less consistent. Until quite recently, HF was the primary means of long-haul military communications.

However, although in use since the early years of the century, HF had, and has, a number of intrinsic disadvantages. While these were acceptable to earlier generations of users, by the 1960s they were becoming increasingly unacceptable for modern applications.

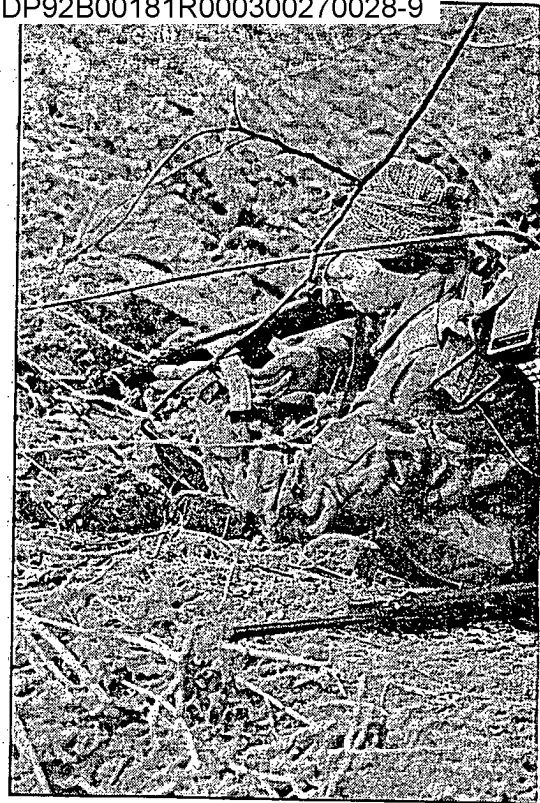
In particular, HF propagation was, and is, subject to ionospheric disturbance and distortion, and graphic coverage is variable. At the same time, some traffic types — including high-speed data communications — were not possible or only possible with a substantial price penalty.

Moreover, since it was extensively used by military and non-military users alike, the HF part of the spectrum was becoming very congested.

At the time HF seemed to be running out of steam, long haul communications using geo-synchronously orbiting satellites were demonstrated to be a practical proposition, particularly for naval communications.

One major user, the US Navy, began to put most of its communications eggs into the

▼ ITT's AN/VRC 89 long/short-range SINCARS set



▲ Marconi's Scimitar system at use in combat conditions

satellite basket, relegating HF to a minor fallback role. Initially lacking the financial and technical resources to construct their own military satellite capability, the European nations continued to develop and refine HF techniques.

A number of events have subsequently caused the reliance on satellites as the only serious element in long haul, non-wired military communications to be questioned.

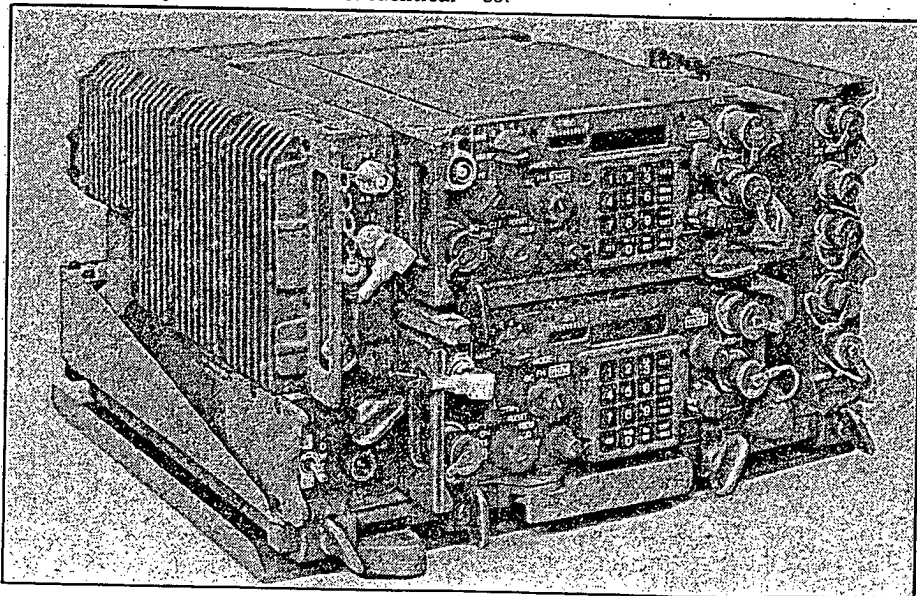
Even before the suspension of the Shuttle programme and the latest failure of the Ariane rocket, the business of actually launching satellites was rather uncertain. There was also the related difficulty of repairing faults *in situ*.

More critical, though, was the recognition that satellites in orbit are highly vulnerable to hostile attack. Since it was possible to destroy an incoming high-speed missile at near-orbital height, went the reasoning, the destruction of a virtually stationary object such as a communications satellite was also achievable.

Growing unease came to a head in the late 1970s in a US exercise which assumed that all friendly satellites had been knocked out by enemy action. Chiefs of staff were alarmed by the 1950s vintage HF technology which remained at their disposal.

These developments were instrumental in the revival of US interest in HF, and spawned such initiatives as the High Frequency Improvement programme and later, the High Frequency Anti-Jam (HFAJ) project.

Today, there is much less hostility to satellite communications than was evident earlier in the decade. The belief is now that a hostile force in practice would not incapacitate friendly satellites, since this would be an unequivocal indication of its





future intentions.

Also, the vulnerability of satellites is not confined to one side or the other, and in a tit-for-tat offensive against satellites, the enemy would probably be inconvenienced in the same measure as the friendly forces.

Electronic warfare (EW) is now an established part of short-range military radio communications and is fast becoming a trend for HF. General Western interest in the various EW technologies was heightened after the studies of the 1970s Middle East conflict showed that the Egyptians were able to use Soviet radio disruption techniques to some effect against the Israelis.

Frequency hopping, which the South Africans claim to have pioneered, is one of the main weapons in the EW armoury.

## Disruption

The basic idea of frequency hopping is that if a number of synchronised transceivers (usually operating in a net in land applications) is changed sufficiently frequently throughout the duration of a message, the disruption or acquisition of the message becomes extremely difficult.

In operation, radios are programmed to dwell for a very short time in a pseudo random sequence on the large number of frequencies which constitute the 'hop set'. Two types of hop set are possible — orthogonal and non-orthogonal.

The first is designed so that there is no mutual interference between different hop sets. With the latter, different hop sets may occasionally use the same frequency at the same time.

However, in operational nets which have a low send-to-receive ratio, the probability of this happening is quite small, and deterioration in performance is negligible.

Non-orthogonal can also make more efficient use of the available frequency spectrum.

To make the task of the enemy even more combined with an encryption capability or, in what are known as hybrid systems, direct sequence modulation. The latter is designed to counter the effects of jamming with increased signal gain.

An example is Telettra's Hydra series of radio sets, one of which — the Hydra/V — is claimed by its manufacturer to give a 9dB advantage when compared to more conventional frequency hopping systems.

Some impressive results have been achieved with frequency hopping. Marconi reports that its Scimitar system has been demonstrated working satisfactorily when placed 100 m away from three 1 kW jammers.

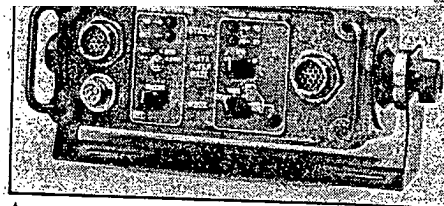
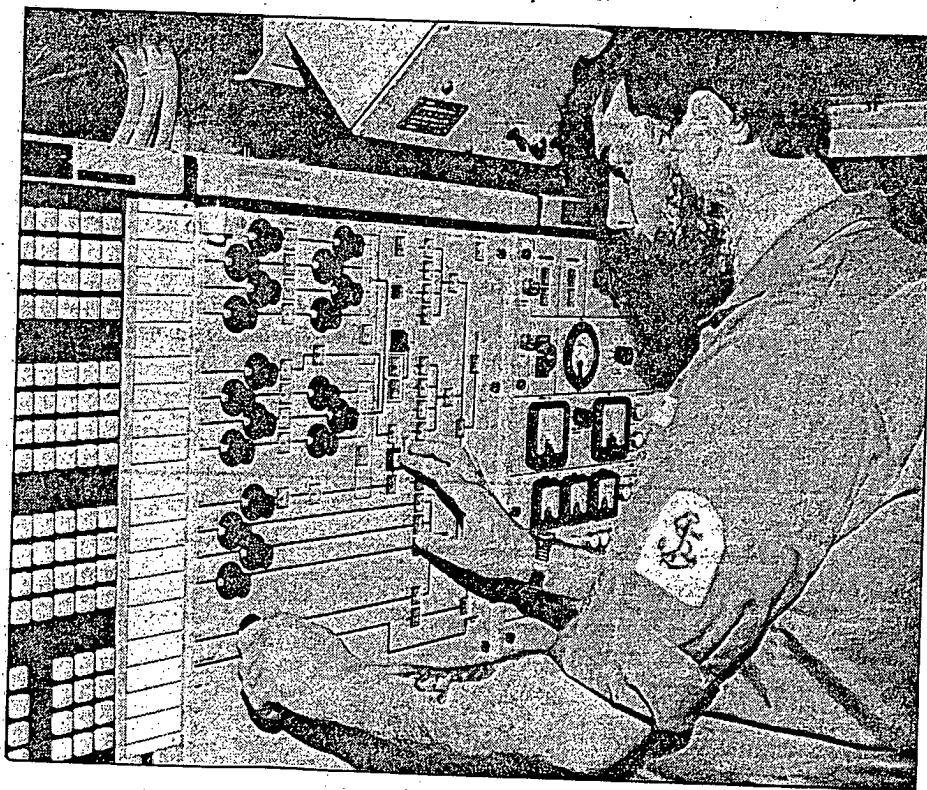
This notwithstanding, some early hopes for the technology have not been fulfilled. The history of one of the major frequency hopping programmes — the USA's single channel ground/air radio system (SINCGARS) is instructive in this regard.

SINCGARS is a \$5.6 billion project designed to furnish a jam-proof replacement for the US Army's old AN/PRC-77 and AN/VRC-12 radios.

Conceived in the mid-1970s, the project initially looked at medium hopping (around 150 hops/sec) and fast hopping (around 2000 changes per second) radio variants, and involved a number of US and joint US/UK manufacturers. In the event, fast hopping proved to be unattainable, and in 1983 ITT was awarded the main contract to produce a 200 hops/sec system.

By the spring of last year, SINCGARS was 12 months behind schedule. Then, last December, representatives of the army and ITT agreed to further restructure the programme. The cause of this was ITT's inability to achieve the MTBF (mean time

▼ Part of the Marconi ICS3 broad-band HF system



▲ Harris Corp's RF-3490 digital data buffer is designed for data applications on the NA/PRC-117 frequency-hopping manpack and AN/VRC-94(V) vehicular transceivers

between failure) levels required by the military.

Although in the course of the year the MTBF of the first examples of the frequency hopping variants of SINCGARS was reportedly lowered from 200 to 400 hours, the official requirement is for 1250 hours.

At present, the army has agreed to accept 300 non-frequency hopping radios in 1989 for field trials in 1990. If successful, the army will then authorise ITT in 1991 to produce 300 frequency hopping sets which must meet the original MTBF specification.

This means that if the reliability problems are sorted out, no large-scale production quantities of frequency hopping radios will be released until around 1994, with exports banned until the turn of the century.

Export markets aside, there are mixed views about what these developments could mean for ITT's competitors in this sector. Some companies envisage a short-term US market opening up with the military buying a proven off-the-shelf frequency hopping system.

Most of such equipment is produced by overseas manufacturers. Leaving aside for political reasons South African (and probably Israeli) sources of supply, European companies such as Marconi, Racal, Plessey, Thomson and Telettra could compete in a market worth tens of millions of pounds.

standards. None of the main rival frequency hopping systems nor would they work with SINCGARS. Modifying equipment to be compatible with SINCGARS in the future might easily go beyond the revised schedule for the introduction of SINCGARS itself, and the spares holding and maintenance tasks would be considerably complicated.

Some observers consider that a more likely outcome will be to attempt to speed up the SINCGARS programme by the appointment of a major second source supplier with experience in frequency hopping technology.

If 300 hops/sec is a medium speed for VHF systems, 100 hops/sec would be quite fast for long haul narrowband links. In simple terms, the faster the rate of hops required, the more the energy that has to be introduced into the system.

This energy is residual, and can produce problems of side-lobes, interference and noise to compound the difficulties of the already less than optimum HF environment.

The relationship between hop rate and the defensive and operational requirement of particular forces is quite complex. An enemy will find it useful to intercept and analyse a friendly force's signal traffic at some times, and shut communications down by jamming on spot frequencies at other times.

To circumvent this, the friendly force frequency hops its communications.

## Hop sequence

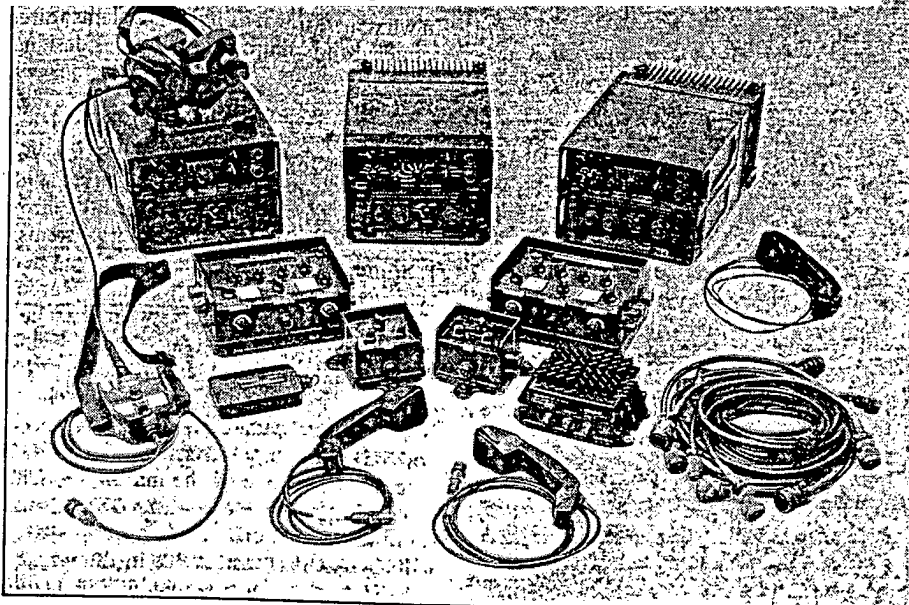
In the first circumstance this leaves the hostiles with the task of replicating the hop sequence and rate to access any message's content. At very high hop rates, the laws of physics intervene and due to the propagation times of signals, it becomes impossible for an enemy receiver to change frequency with sufficient rapidity to accomplish its task.

So far as jamming is concerned, frequency hopping can be countered by either using a follower jammer or spreading power over a wide frequency band.

In both cases, the amount of power available to the jammer on any one frequency will probably be lower than that originally transmitted. This means that to succeed in its task, the jammer will be obliged to move closer to its target, thereby providing some opportunity for cat and mouse manoeuvring on the part of the friendly force until the source of disruption is brought within range of defensive assets.

Among the survivors of the recent US enthusiasm for HF is the HFAJ. Originally inspired by the US Navy, HFAJ now has multi-service applications and could be worth an initial \$3 billion to an equipment supplier.

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▲ Harness system for the Scimitar family of radios

The technological requirement has so far proven so complex that only proposals submitted by a team led by Rockwell and Marconi, and supported by Westinghouse and Magnavox, have received serious attention.

Although this singularity flies in the face of conventional US procurement practices, the partners are optimistic that they will get the go-ahead.

Latest reports suggest that the first HFAJ contracts will be announced in March, and involve systems for the US Navy. These will be based on Marconi's ICS3 broadband system architecture, which is used by the Royal Navy, the Royal Netherlands Navy and the Hellenic Navy, and has been sold to the US Navy for use in its new LHDI class of combined assault ships.

ICS3 is a broadband system which, its manufacturers argue, has key advantages when it comes to frequency hopping at HF. The system's architecture enables all transmissions to be amplified and radiated simultaneously using a single power bank of amplifiers and broadband antennas. This arrangement removes the need for any RF mechanical units.

The net result is that frequency changes are relatively fast, and can be made in rapid succession.

Additionally, the radiated HF power can be adjusted instantly and independently for each frequency, and the separation between adjacent HF channels can be reduced to as little as 50 kHz.

Moreover, narrowband HF and MF channels can be incorporated to suit

particular users' requirements. ICS3 has the US nomenclature AN/URC-109.

Not all armies or navies share the US belief in the value or practicality of frequency hopping in modern military communications.

The British Army, for example, has not yet made a final commitment to the technology, although it has conducted trials with Racal's Jaguar and Marconi's Scimitar systems.

In part, these trials were designed to test the feasibility of managing large numbers of frequency hopping radios in very close proximity — an environment which would be encountered in a European theatre of war. Initial scepticism has apparently been reduced after 100 radios were operated satisfactorily inside a single field.

In the absence of a large home market, UK manufacturers have had to turn their attentions abroad where, indeed, they have had some considerable success in selling the idea and the technology.

Racal has sold over £70 million worth of its system, a sum which includes a £20 million deal with Oman.

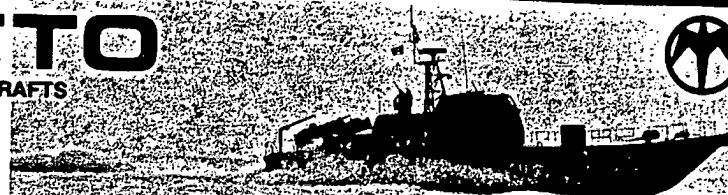
Australia's planned Raven system, in which Plessey is the major contractor, has major frequency hopping capabilities.

Meanwhile, Marconi has most recently been awarded a £40 million-plus contract to supply derivatives of its broadband Scimitar system to the Swedish Army and elements of the Swedish Navy.

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